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MECHANICAL

E. V. Konopatskiy, I. G. Balyuba
Modeling the contour arc based on Dezargues configuration

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A new geometric algorithm for modeling the contour arc in the form of a curve of one relationship based on the Dezargues configuration, parameterization of which is performed using the mathematical apparatus "Point Calculus", is proposed. The analysis has shown that the obtained contour arc has interesting geometric properties, which can potentially be used for modeling one-dimensional and multidimensional outlines of high order smoothness, which constitutes a prospect for further research. A detailed description of the process of parametrization the contour arc in the point calculus based on the proposed geometric algorithm for its construction with the exception of cumbersome transformations is presented. The given methods of parametrization of geometrical objects in the point calculus on the basis of a simple relation of three points of a straight-line invariant concerning parallel projection, can be used by other researchers for the solution of a wide range of problems of engineering geometry and computer graphics. Examples of modeling spatial and planar, closed and unclosed arcs of the circumference, which can find their application as shape-forming elements of surfaces of technical forms, are given.

Keywords: Dezargues configuration, contour arc, geometric algorithm, point calculus, order of smoothness, tangent.

A. A. Novikov, A. R. Putintseva
Improving the efficiency of sanitation of urological catheters with various types of exposure to ultrasound emitters

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The purpose of the article is to determine rational modes for safe and effective ultrasound exposure in order to sanitation urological catheters. It is shown that using an amplitude-modulated or pulsed power supply mode, it is possible to achieve an increase in amplitude, i.e. to improve the quality of cleaning and reduce heat generation. As a result, to technological solutions for the initiation of an ultrasonic emitter have been proposed.

Keywords: ultrasound, emitter, sanitation, obstruction, amplitude-modulated power supply, pulse power supply.

A. A. Novikov[1], A. R. Putintseva[1],
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Study of the passage of low-frequency ultrasonic vibrations through heterogeneous biological media during ultrasonic sanitation of urological catheters

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The purpose of this article is to study the features of the passage of ultrasonic vibrations through inhomogeneous biological media. To achieve the goal, a mathematical model for the propagation of ultrasonic vibrations in heterogeneous media has been developed, and clinical studies have been carried out. It is shown that the proposed calculation method can be used to evaluate the passage of ultrasonic vibrations through inhomogeneous biological media. Recommendations on the choice of topographic landmarks of ultrasound exposure for non-invasive sanitation of urological catheters are made.

Keywords: ultrasound, intensity of ultrasonic vibrations, acoustic impedance, debridement, obstruction, ureteral stent.

D. I. Chernyavsky[1], D. D. Chernyavsky[1],
A. A. Panyutich[2]
Determination of strength characteristics of elements of long-stroke piston compressor

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The work analyzes the strength calculation of the long rod of the piston of the long-stroke piston compressor designed to obtain excess gas pressure. The pressure increase in one compressor stage can increase to 120 times the initial gas pressure. Criteria of strength calculation of piston rod are defined at which it is necessary to use either method of rod calculation for strength or model of rod calculation for stability. Conclusions have been drawn and practical recommendations are given that can be used in the design of compressor stages.

Keywords: long-stroke piston compressor, strength calculation, loss of stability of compressed rods, critical compression force of Euler, Poisson adiabate.

A. A. Dubanov[1], T. V. Ausheev[2]
Pursuit on the plane by objects moving away from the trajectory of defending object, with simulation of detection area

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This article describes the model of pursuit of a single target by the method of chasing a group of objects. All objects participating in the pursuit model move with a constant modulo speed. The pursuing object moves along a certain trajectory and releases objects at specified intervals, the task of which is to overtake the target by the chase method. Released objects have restrictions on the curvature of the motion path. A single target, in turn, is tasked with overtaking the pursuer by the method of parallel approach. For each pursuing object, a detection area is formed. The detection area is formed by two beams. The object's velocity vector is the bisector of the angle formed by such rays. If the target enters the detection area, then the object begins the pursuit by the chase method. If the target leaves the detection area, then the object makes a uniform and rectilinear movement. The task is to implement a dynamic model of multiple group pursuit, where each object has its own tasks, which implements the chase method. The model is developed using computer

mathematics systems. Based on the results of the research, animated images are created. As an example, where the model developed in the article could be in demand, the following can be given. There is considered the motion of a low-maneuverable object that is overtaking a faster target. As a means of protection, instead of releasing passive heat traps, it is proposed to drop a multitude of autonomously controlled weapons of destruction. From the analysis of the media, descriptions of such means of protection for aircraft have not been found. Modeling is carried out on a plane, there are no obstacles for modeling in space. The results of the research can be in demand in the design of unmanned aerial vehicles with elements of autonomous control and artificial intelligence.

Keywords: Parallel pursuit, chase method, target, pursuer, trajectory, correction.

V. A. Ilinykh, V. Yu. Lineytsev
Analysis of vibrations of rolling bearings of machine mechanisms

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The article analyzes the vibrations of rolling bearings and their influence on the operation of bearings. An increase in the speed of operation and a boost in power and forces cause an increase in the intensity of vibration fields. The impact of vibrations leads to a change in the characteristics of the contacting surfaces, an increase in friction at the joints and heating of the conjugations. The article describes the factors disturbing vibrations in the joints of machine parts. Ways to reduce vibrations are formulated, including as a result of the use of various lubricants. The analysis of the operability of the rolling bearings of the machine components before and after the use of repair and recovery compounds in lubricants is carried out. The use of repair and restoration compounds based on mineral additives and its addition to the lubricant makes it possible to evaluate the effectiveness of repair and restoration compounds on the processes of friction and wear in rolling bearings. The use of liquid lubricants with mineral additives with a particle dispersion of up to 10 microns during lubrication makes it possible to reduce the noise level and significantly reduce the vibration level in the rolling bearings of machine mechanisms.

Keywords: rolling bearings, repair compositions (RVS), mineral additives, lubricants, vibration level, noise level.

A. G. Kisel, D. S. Makashin
The influence of lubricating coolant and processing modes on surface roughness during face milling of workpieces made of aluminum alloys

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Within the framework of these studies, experimental studies are carried out on the effect of using coolants of various types — synthetic «BIOSIL-S», semi-synthetic «SP-3» and water-based «Smalta-4» — on the roughness of the machined surface of an aluminum billet during milling. The roughness of the machined surface is evaluated by the Ra parameter using a MarSurf PS1 portable profilometer. As a result of the research, it is found that coolants affect the quality of the resulting surface in different ways. The best surface quality is obtained at a cutting speed of V = 283 m/min and a feed of S = 0,02 mm/tooth using a BIOSIL-S coolant, which is due to rational cutting conditions and the physical properties of the coolant.

Keywords: lubricating coolant, lubricating coolant efficiency, density, empirical dependence.

L. K. Sirotina
Methodological approaches and goal-setting for development of indicators of production manufacturability of orders and processes

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The article is devoted to the problem of forming the necessary reference information about the generalized indicators of the production manufacturability of products, orders and processes based on the results of organizational preparation when planning the order-by-order production of small-scale products of textile and clothing enterprises. The development of the necessary background information on the indicators of material intensity and labor intensity of orders will allow to systematize the process of their comprehensive preparation and production planning, taking into account the existing organizational and technical conditions and efficiency requirements. The approaches, the purpose and objectives of calculation and the directions of evaluation of generalized indicators of production manufacturability of orders and processes for the needs of volume and calendar planning of production in the conditions of enterprises of the studied industry are described.

Keywords: preparation of production, manufacturability of the order, textile enterprise, sewing enterprise, calendar and planning standards, material consumption of the order, raw material balance, labor intensity of the order.

Yu. O. Filippov
The studies of using composite material for temporary repair of shut-off valves on main oil pipelines

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The paper presents the results of studies of composite materials based on epoxy resins with different types of filling are considered. It is shown that a material with a metal filler has higher mechanical characteristics compared to a material filled with ceramics. The material retains high mechanical properties at low temperatures and after interaction with petroleum products. Hydraulic tests showed that the material with a ceramic filler withstood only on non-through defects. The metal-filled material has passed the tests for non-through defects and through defects at pressures up to 4,0 MPa. The material with a filler based on Fe and Cr powder can be used in pipeline construction for temporary repair of valves with non-through defects or through defects of valves operating up to 1,6 MPa.

Keywords: pipeline fittings, temporary repair, composite material, mechanical properties, hydraulic tests.

F. F. Khabibullin, R. T. Islamov, T. A. Mustafaev, V. N. Krymova
Investigation of the kinematics of mechatronic device drive based on a spatial mechanism

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In this paper, we consider the scheme of mechatronic device based on a spatial mechanism. The scheme is designed in such a way that the working elements are combined with the elements of the transmission mechanism — links. In the basis of design there are combined two basic modules with the discarding of the corresponding common links and the hinge, resulting in a new device. In addition, special attention is paid to values of absolute angular velocity and angular acceleration of a link for a particular point, also linear velocities and accelerations for each

point of interest of a link from which the radius-vector and position of a point in space are determined. On the basis of the made calculations the scheme of an agitator with 4 links-blades, working bodies of which are combined with elements of a transfer mechanism, is proposed.

Keywords: spatial mechanism, four-link mechanism, drive, crank, kinematics study, mechanism synthesis.

A. H. Shamutdinov[1], I. Yu. Lesnyak[2]
Simulation of dynamics of oscillations of manipulator using Lagrange equations of second order

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The article discusses the main stages of compiling a dynamic model of manipulator oscillations, based on the method of mathematical modeling, the basis of which is the circuit design of the manipulator under study. A schematic solution of the manipulator has been compiled as a system in which an arbitrary vertical force Pz and moments Mx, My relative to the X and Y axes act on the working panel, elastic elements — springs, with known stiffness coefficients. On the basis of the equation of dynamics, in the form of Lagrange of the second order, a system of equations of oscillatory processes arising from external loads is compiled, natural frequencies of elastic oscillations of the manipulator are determined, and conclusions are drawn.

Keywords: manipulator, working panel, inclined panel, turntable, stiffness coefficient, Lagrange equations, matrix of inertia and stiffness.

V. I. Yadrov, A. V. Pepelyaev,
S. D. Gerasimov, V. S. Weber
Implementation of the program process of preparation for starting tank engine under low temperatures

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In the presented work, the justification of the need to install a system of the program process of starting the heater on the objects of armored vehicles is given. The analysis of the currently available works on this topic is made. According to the authors, the main shortcomings in the proposed approaches to solving the problem are identified. The article proposes a technical solution that allows to minimize the participation of the driver in the pre-start preparation of the tank engine. A forecast is made for further improvement of the developed system, which allows to significantly raise the level of combat readiness of military units.

Keywords: engine pre-start preparation, microcontroller, control unit, actuator, heater, combat readiness, low temperature conditions.

L. R. Safarova, S. V. Kasyanov, D. T. Safarov
Designing technologies for life cycle of associated products and waste in process of preparing production of a new automotive component

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The article presents an approach to minimizing the impact of automotive production on the natural environment, while minimizing the consumption of resources due to adequate planning of waste generation volumes in the workplace and the development of their life cycle processes at the stage of preparing the production of an automotive component. The algorithm of designing the manufacturing technology of automotive components with the development of processes for generating all types of associated products in the workplace is given. The blocks of calculation procedures are synchronized with the stages of preparation for the production of a new product in the automotive industry. A method of structuring the process has been developed, modeling of the content of intraoperative processes of creating a marketable product and the formation of time chains with subsequent planning for the removal of associated products, waste and emissions in the processes of functioning and maintenance of workplaces is carried out. Economic calculations are performed for decision-making by the engineering services of the enterprise.

Keywords: integrated quality management system, associated products, wastes, emissions, planning, wastes management, project production preparation.

ENERGY AND ELECTRICAL ENGINEERING

A. A. Kuznetsov, V. V. Kharlamov, M. A. Volchanina
Algorithm for diagnosing insulation of power transformers by acoustic method in conditions of temperature changes

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The article presents an algorithm for processing data by the acoustic method of insulation power transformers. The article presents data processing of diagnosing by the acoustic method of power transformers. A feature of the power supply system of railway transport is the location of traction substations along the railway track. For diagnosing power transformers advisable to use portable systems based on acoustic monitoring of partial discharges due to their high mobility and ease of installation. To improve the reliability of diagnosis under the conditions of seasonal temperature changes proposed use a defect simulator and a differential method for measuring the parameters of partial discharges. The scheme of the experiment and the diagnostic algorithm are proposed. Expressions are given that describe the properties of transformer oil with temperature changes, and changes in signal parameters during the propagation of acoustic waves. The data of diagnostics obtained on a power transformer at positive and negative temperatures under conditions of development of an insulation defect accompanied by partial discharges are presented.

Keywords: power transformers, acoustic method, partial discharges, insulation diagnostics, defect simulator, signal parameters.

A. A. Kuznetsov, A. V. Ponomarev,
A. Yu. Kuzmenko, G. V. Volchanin
Determination of corrosion state of reinforced concrete structures by the parameters of color change in video image

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The article shows one of the factors influencing the formation of corrosion of hollow reinforced concrete structures — leakage currents in insulators. The development of corrosion depends on the amount of electricity that has passed through the reinforced concrete. A method for controlling the corrosion state by changing the color parameters on the video image of the reinforced concrete surface is proposed. A full-scale experiment is carried out on samples simulating various degrees of corrosion, as well as on a sample with an unknown level

of corrosion. The images are obtained using an industrial endoscope.

Keywords: reinforced concrete supports, corrosion, leakage currents, insulators, visual control, video image, color parameters.

V. I. Gorbunkov, M. A. Kholmov, A. V. Iukina, I. V. Ksendzov, V. A. Zhigadlo
The dynamic effect of electric charge on a conductor

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An estimate of the dynamic effect the electric fields of a charged sphere on a current-carrying conductor is obtained. The characteristic time parameter of charge transfer to a conducting sphere, as well as the momentum Conservation Principle are applied. The found values of the interaction force and the transmitted energy can make it possible to determine the physical nature of the dynamic effect. A description of the laboratory setup is presented.

Keywords: Coulomb interaction, Ampere's law, sphere field, conductor with a current near a charged sphere, Momentum Conservation Principle.

S. G. Shantarenko
Features of construction of modern systems for automatic power redundancy of traction substations DC

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The article presents the results of studies on improving the efficiency of electrical power redundancy systems in power supply systems of railway DC vehicles by improving the technological modes of traction substations. There are presented scientifically based technical solutions of the hardware, a control algorithm of the power reserve system for traction substations with two converter units and a methodology for selecting places for installing automatic power reserve systems to increase the efficiency of the power supply system for railway vehicles. Practical testing of the developed technical and technological solutions has shown the effectiveness of their use in operating conditions.

Keywords: electrical complex, power reserve system, converter unit, traction substation, control algorithm.

ELECTRONICS, PHOTONICS, INSTRUMENT ENGINEERING AND COMMUNICATION

S. V. Biryukov[1], L. V. Tyukina[1], A. V. Tyukin[2]
Experimental studies of dual electric induction spherical electric field intensity sensor in inhomogeneous field of point source

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In the work, dual electroinductive spherical sensors, which are a constructive combination of two double sensors into one, are subjected to experimental studies in a non-uniform electric field. Dual sensors are an integral part of a new method for measuring inhomogeneous electric fields by average value. Experimental studies are aimed at confirming the possibility of using dual sensors in inhomogeneous electric fields and the method of measuring the electric field strength by the average value. To carry out experiments in a non-uniform electric field, a high-voltage measuring setup is created. The measuring setup made it possible to obtain the static characteristics of a dual sensor in an inhomogeneous electric field. Comparison of the static characteristics obtained in a homogeneous and inhomogeneous field makes it possible to estimate their errors and compare these errors with theoretically calculated ones. The comparison results have showed that the discrepancy between the static characteristics does not exceed +1,5 %, and the discrepancy in the errors of the dual sensor, estimated from experimental data in an inhomogeneous field and obtained theoretically, does not exceed ±2 % in absolute units. The obtained research results allow us to confirm the adequacy of the theory underlying the theoretical provisions laid down in the calculations of dual electric induction spherical strength sensors of the electric field.

Keywords: experiment, uniform field, inhomogeneous field, electric field strength, dual sensor, measurement method.

V. Yu. Kobenko, S. O. Frolov, R. F. Ganeev
Application of identification method for control of bearing wear

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The work is devoted to the problem of bearings wear control of during their operation. Well-known methods for control the state of bearings to solve this problem are described. The use of the technology of identification measurement of signals to control the degree of wear of bearings is considered.

Keywords: vibration signal, defect, bearing wear, identification measurements, state control.

V. V. Zaitsev, K. S. Fadeev, K. V. Avdeeva
Development of a mathematical model of magnetically controlled ferrovariometer control circuit

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The objective of this work is to develop a mathematical model for studying the magnetic control field of a magnetically controlled ferrovariometer in a linear approximation. This problem is solved on the basis of a plane-parallel model. The solution is based on the method of secondary sources. On the basis of the developed mathematical model, a program is compiled in a high-level language that provides input of initial data and their printing, calculation of the coordinates of secondary sources and calculation of the initial approximate value of the associated currents, as well as iterative calculation of the system of equations with a given accuracy. The described method and program make it possible to obtain an approximate picture of the distribution of the control field in the design of a magnetically controlled ferrovariometer and in the surrounding space, if the design can be represented by a plane-parallel model. Based on the field calculation, it is possible to perform a parametric synthesis of the control circuit design and evaluate its interfering effect on the surrounding electrical circuits.

Keywords: ferrovariometer, mathematical model, control circuit, magnetic circuit, magnetic field, ferrite.

E. V. Leun, A. E. Shakhanov, S. Yu. Samoilov, A. Yu. Kolobov
Improving the circuitry of high-precision high-speed acousto-optic laser interferometers of displacements with frequency matching of component blocks and double heterodyning at phototransformation stage

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The article discusses the development of the circuitry of acousto-optic (AO) laser displacement interferometers

(LDI) and the values of resolution and speed of controlled displacements achieved by them.
The issues of frequency matching of blocks of AO LDI are discussed: AO modulator, photodetector device (FDD) and frequency generator. The features of phototransformation of the FDD under its illumination by three spatially combined optical streams are studied. Of these, two streams are of different frequencies, created as a result of diffraction in the AO modulator and are used to measure the phase shift from the controlled displacements of the object in the AO LDI. The third optical stream is amplitude-modulated with a frequency close to the difference frequency of the first two optical streams. This technique leads to a twofold transfer (double heterodination) of the phase shift from the offsets to the electrical signal of the difference frequency between the three optical streams.
The schemes of AO LDI with a constant value of the frequency of the amplitude-modulated optical flow and with its auto-tuning are considered. The features of the use of cooled FDD in AO LDI are discussed.

Keywords: laser displacement interferometer, optical signal heterodination, photodetector noise, generator jitter, signal filtering, cooled photodetector, frequency auto-tuning.

**A. A. Versin, A. M. Molchanov,
V. P. Monahova, V. A. Afanasiev**
Development of mathematical model of gas flow for calibration stand of full and static pressure receivers

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The paper proposes a mathematical model for calculating the main parameters of a controlled gas flow in the process of designing and creating a calibration stand for static and total pressure receivers, which allows, before the stand certification, to identify the features and pattern of the distribution of these parameters along the radius and length of the gas flow jet. Obtaining a given controlled gas flow, in turn, is associated with the calculation and manufacture of the nozzle. The paper proposes the use of a subsonic nozzle calculated according to the Vitoshinsky formula, which allows creating a given gas flow rate in the working part of the calibration stand depending on the gas flow rate (three modes are considered). The results of calculation of such gas flow parameters as longitudinal velocity, static pressure and static temperature at different distances from the nozzle exit (at the nozzle exit, at a distance of 2Ra, at a distance of 5Ra) are presented.

Keywords: calibration stand, nozzle, mathematical model, velocity profile.

L. V. Tyukina[1], S. V. Biryukov[1], A. V. Tyukin[2]
A new approach to application of the method of measuring electric field strength by average value

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[2]Siberian State Automobile and Highway University, Omsk, Russia**

The paper considers a new possibility of using the method of measuring the electric field strength by an average value in order to reduce the error from the inhomogeneity of the field and expand the spatial range of measurements. The studies carried out in the work allowed us to establish that when using the measurement method by the average value, there are always three values at each measurement step, two of which correspond to the two previous values of the EP intensity determined with errors opposite in sign, and the third corresponds to the average value of them. Therefore, in the work, it is proposed to measure the electric field strength at one point in space by two sensors with errors opposite in sign. At the same time, alternately determining at each step of averaging the average value of the EP intensity from the previously obtained and subsequent average values, bringing the measurement result closer to the true value. Based on the results of theoretical research, a new method is proposed — the "Measurement method with step-by-step averaging", which, without complicating the measurement process, makes it possible to reduce by two to three times the error in measuring the intensity of inhomogeneous electric fields in a wide spatial range compared with the measurement method by the average value.

Keywords: inhomogeneous electric field, electric field strength, dual sensor, measurement method by average value, step-by-step averaging.

**Ye. Altay, A. V. Fedorov,
K. A. Stepanova, D. O. Kuzivanov**
Estimating efficiency of acoustic emission signal processing methods in implementation of polynomial digital filters

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The article presents a method for processing an acoustic emission (AE) signal to extract information and noise components from a noisy record. The method is based on digital filtering by polynomial models. To compensate for the introduced distortions by filters, a scheme for bi-directional processing of the AE signal is proposed. The operability of the filtering method for a noisy record is analyzed, and processing is evaluated on the basis of quantitative indicators. The evaluation results showed that the presented filtering method provides stability to the influencing noise and high accuracy of processing the AE signal recording when compared with the closest analogues.

Keywords: acoustic emission signal, digital filter, Butterworth polynomial, processing accuracy, noise-resistance processing, bi-directional filtering, signal-to-noise ratio.